

## Purple Nutsedge (*Cyperus rotundus*) Population Dynamics in Narrow Row Transgenic Cotton (*Gossypium hirsutum*) and Soybean (*Glycine max*) Rotation<sup>1</sup>

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**Abstract:** A 4-yr field study was conducted during 1998 through 2001 at Stoneville, MS, to determine the effects of narrow-row transgenic cotton and soybean rotation on purple nutsedge populations and crop yield. Crop rotations over 4 yr included cotton and soybean sown in the following patterns: CCSS, CSCS, SCSC, SSCC, and continuous cotton (CCCC) and soybean (SSSS), where cotton is denoted as (C) and soybean as (S), all with herbicide programs that were glyphosate based, non-glyphosate based, or no purple-nutsedge control (NPNC). Purple nutsedge populations and shoot dry biomass were reduced in cotton and soybean rotation and continuous soybean by 72 and 92%, respectively, whereas in continuous cotton, purple nutsedge populations increased by 67% and shoot dry biomass was reduced by 32% after 4 yr. Reductions in purple nutsedge populations also occurred in soybean when cotton was rotated with soybean (CSCS and SCSC), compared with continuous cotton. Among herbicide programs, the glyphosate-based program was more effective in reducing purple nutsedge populations, compared with the non-glyphosate-based program. Seed cotton yield was greater with cotton following soybean (SCSC) than with cotton following cotton (CCCC, CCSS) in 1999. However, seed cotton yields were similar regardless of crop rotation systems in 2000 and 2001. Seed cotton yields were equivalent in the glyphosate-based and non-glyphosate-based programs in 1999 and 2001. During 1999 to 2001, seed cotton yields were reduced by 62 to 85% in NPNC compared with yields in glyphosate- and non-glyphosate-based programs. Soybean yields were unaffected by crop rotation systems in all the 4 yr. Among herbicide programs, non-glyphosate-based program in all 4 yr and glyphosate-based program in 1999 and 2000 gave higher soybean yield compared with NPNC. After 4 yr of rotation, purple nutsedge tubers and plant density were highest in continuous cotton and lowest in continuous soybean. Both herbicide programs reduced tubers per core and plant density compared with NPNC, and the glyphosate-based program was more effective than the non-glyphosate-based program. These results show that in cotton production, severe infestations of purple nutsedge can be managed by rotating cotton with soybean or by using glyphosate-based herbicide program in glyphosate-resistant cotton.

**Nomenclature:** Glyphosate; purple nutsedge, *Cyperus rotundus* L. #<sup>3</sup> CYPRO; cotton, *Gossypium hirsutum* L. 'DP 436RR'; soybean, *Glycine max* (L.) Merr. 'DP 5806RR'.

**Additional index words:** Purple nutsedge tuber, transgenic crop.

**Abbreviations:** fb, followed by; NPNC, herbicide program with no purple-nutsedge control; POST, postemergence; PPI, preplant incorporated; PRE, preemergence.

### INTRODUCTION

Purple nutsedge is considered the world's worst weed (Holm et al. 1977). It is an invasive and difficult to control weed in row crops, lawns, pastures, and other areas in the southern United States (Wills 1987). Tubers are the primary means of propagation and spread of purple

nutsedge (Hauser 1962; Stoller and Sweet 1987; Wills and Briscoe 1970), and a single tuber may give rise to more than 100 additional tubers in 3 mo (Kim et al. 1994). The longevity of the tubers, the ability to sprout several times (Keeley 1987), and the lack of herbicides that can kill dormant tubers make purple nutsedge difficult to control. Because purple nutsedge is considered one of the most troublesome weeds in cotton (Keeley and Thullen 1971; Keeley et al. 1972), there is a greater need to find profitable crop production systems that control this pernicious weed without increasing production costs (Bryson et al. 1990, 1994).

Several herbicides labeled for cotton (Holt et al. 1962;

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<sup>3</sup> Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

Keeley and Thullen 1971; Keeley et al. 1972; Wilcut 1998; Wills and McWhorter 1988) and soybean (Anonymous 2000; Bariuan et al. 1999; Reddy and Bendixen 1998) provide various levels of purple nutsedge control or suppression. Shading of tuber-infested soils reduces purple nutsedge emergence (Patterson 1982). Sustaining purple nutsedge suppression long enough to allow shading from crop canopy closure in cotton usually provides temporary competition and subsequent relief from purple nutsedge interference (Bryson et al. 1990). Because some tubers remain dormant and those that sprout produce additional plants and tubers between planting and canopy closure, continual purple nutsedge pressure is common year after year, especially in cotton production. The slow growth characteristics of cotton, plant morphology, and wide row spacing (ca. 1 m) provide an excellent environment for rapid purple nutsedge growth. Yield reductions due to interference by purple nutsedge are reported to be as high as 45 and 58% in cotton and soybean, respectively, in the Philippines and India (Guantes and Mercado 1975; Kondap et al. 1982).

With the commercialization of glyphosate-tolerant crops, glyphosate offers another alternative to manage purple nutsedge and potentially reduce population levels over time (Bariuan et al. 1999; Kim et al. 1994; Wang 2002). Recently, there has been a renewed interest in producing cotton in a rotation with other crops and using transgenic weed control technology. In narrow-row (< 25 cm wide) crop production, crop canopy closure occurs earlier than in rows wider than 50 cm apart (Reddy 2002).

The objective of this research was to determine the effects of narrow-row glyphosate-resistant cotton and soybean rotation systems on purple nutsedge population and purple nutsedge control and crop yield. Our hypothesis was that an integration of transgenic weed control technology, crop rotation, and narrow row spacing would reduce purple nutsedge populations.

## MATERIALS AND METHODS

Research was conducted during 1998 through 2001 at the USDA-ARS Southern Weed Science Research Farm, Stoneville, MS (33° N), on a Dundee silt loam (fine-silty, mixed, thermic Aeric Ochraqualfs) soil with pH 6.7, 1% organic matter, a cation exchange capacity of 15 cmol/kg, and soil textural fractions of 26% sand, 56% silt, and 18% clay. The experimental area was naturally infested with purple nutsedge. Before the initiation of the study, for 2 yr, the experimental area was tilled in the spring, fertilized, treated with a combination of herbicides (tri-

fluralin preplant incorporated [PPI], fluometuron pre-emergence [PRE], bentazon postemergence [POST] each at 1.1 kg ai/ha and clethodim at 0.14 kg ai/ha POST) to select for purple nutsedge, and irrigated from May to August as needed to establish abundant and uniform distribution. Field preparation consisted of fall disking and bedding. In the spring, beds were harrowed nearly flat to enable irrigation and planting in narrow rows. Before crop planting, the experimental area was treated with paraquat at 1.1 kg ai/ha to kill existing vegetation. Glyphosate-resistant cotton cultivar 'DP 436RR' was planted on June 3, 1998; May 20, 1999; May 1, 2000; and May 2, 2001, at 312,000 seeds/ha using a Monosem NG Plus precision planter<sup>4</sup> in 25-cm rows. Glyphosate-resistant soybean cultivar 'DP 5806RR' was planted on June 10, 1998; May 3, 1999; May 2, 2000; and May 2, 2001, at 450,000 seeds/ha with a grain drill<sup>5</sup> in 19-cm rows. Planting of cotton and soybean was delayed in 1998 because of rainfall. Crops were furrow irrigated at the rate of 5 cm water as needed on August 8, 1998; July 8, 1999; July 24, 1999; July 14, 2000; and August 4, 2000, and crops were not irrigated in 2001. Fertilizer application and insect control programs were standard for cotton production (Reddy 2001). Cotton plant height was kept below 90 cm by applying mepiquat chloride (*N,N*-dimethylpiperidinium chloride) POST at first match-head square stage, followed by (fb) a second application 2 wk later. Harvest preparation consisted of defoliation by tribufos (*S,S,S*-tributyl phosphorotrithioate) at 1.5 kg ai/ha and boll opening by ethephon ((2-chloroethyl)-phosphonic acid) at 1.1 kg ai/ha fb desiccation with paraquat.

The experimental plot consisted of 16 rows spaced 25 cm apart in cotton and 20 rows spaced 19 cm apart in soybean and 12.2 m long. The experiment was conducted in a split-plot arrangement of treatments in a randomized, complete block design with crop rotation (CCCC, CCSS, CSCS, SCSC, SSCC, and SSSS—cotton is denoted by C and soybean by S) as main plots and herbicide programs as subplots with three replications. Herbicide treatments in cotton included: (1) metolachlor (1.1 kg ai/ha), fluometuron (1.1 kg ai/ha), and pyriithiobac (0.04 kg ai/ha) PRE fb pyriithiobac (0.08 kg ai/ha) POST (non-glyphosate); (2) glyphosate (1.1 kg ai/ha) POST at one-leaf cotton fb glyphosate (1.1 kg ai/ha) POST at four-leaf cotton (glyphosate based); and (3) a herbicide program with little to no activity on purple nutsedge (NPNC) including fluometuron at 1.1 kg ai/ha PRE and

<sup>4</sup> Monosem NG Plus ultra narrow row precision planter, Monosem ATI, Inc., 17135 West 116th Street, Lenexa, KS 66219.

<sup>5</sup> John Deere 750 series grain drill, Deere and Co., 501 River Drive, Moline, IL 61265.

clethodim at 0.14 kg ai/ha POST to control other weeds. Herbicide treatments in soybean included (1) metolachlor (2.8 kg ai/ha) PRE fb chlorimuron (13 g ai/ha) POST (non-glyphosate); (2) glyphosate (1.1 kg ai/ha) POST fb glyphosate (1.1 kg ai/ha) POST at 3 and 5 wk after soybean planting (glyphosate based); and (3) NPNC including acifluorfen at 0.4 kg ai/ha, bentazon at 1.1 kg ai/ha, and clethodim at 0.14 kg ai/ha POST to control other weeds. A dinitroaniline at 1.1 kg ai/ha (pendimethalin or trifluralin) was applied PPI to the entire experimental area 3 to 4 wk before planting. Herbicide treatments were applied with a tractor-mounted sprayer with TeeJet 8004 standard flat fan spray tips delivering 187 L/ha water at 179 kPa.

Purple nutsedge shoots were counted in three randomly selected quadrats of 1 m<sup>2</sup> within each plot. Shoot dry weight of purple nutsedge was recorded from three 0.25-m<sup>2</sup> areas within each quadrat previously mentioned (except in 1999). Shoot and dry weight data were collected during midseason about 3 wk after the second POST application. Cotton was manually harvested from the center four rows of 1 m length in 1999 and 2 m length in 2000 and 2001. Cotton plants and open bolls were also determined from these areas. Soybean was harvested from the entire plot using a combine, and grain yield was adjusted to 13% moisture. Seed cotton was not harvested in 1998 because of extensive yield loss caused by high boll weevil populations that emigrated from an adjacent untreated (insecticide free) field. Overall effect of rotation system on purple nutsedge population was assessed at the end of a 4-yr rotation. Five soil cores (9.5 cm in diameter and 15.2 cm deep) were collected at random from each plot on November 1, 2001, and tubers were counted. Purple nutsedge shoots were counted from two randomly selected quadrats of 1 m<sup>2</sup> from each plot on May 1, 2002.

The data were subjected to an analysis of variance using Proc Mixed to determine significance of main effects and any interactions among main effects (SAS 1998). Treatments were separated at the 5% level of significance using Fisher's protected LSD test. Data were combined for years if interactions were not significant and are presented for interactions where appropriate.

## RESULTS AND DISCUSSION

**Purple Nutsedge Density and Biomass.** There were no differences in purple nutsedge populations among rotation systems in 1998, the first year of study (Table 1). However, differences in purple nutsedge populations became apparent in subsequent years of rotation. Purple

Table 1. Purple nutsedge plant density as affected by non-glyphosate- and glyphosate-based herbicide programs in 4-yr, narrow-row, glyphosate-resistant cotton and soybean rotation systems.<sup>a,b</sup>

Rotation system	Herbicide program <sup>c</sup>	Purple nutsedge density			
		1998	1999	2000	2001
CCCC	No glyphosate	74	139	358	254
	Glyphosate	39	9	4	9
	NPNC	302	254	576	425
	Mean	138	134	312	230
CCSS	No glyphosate	132	130	120	15
	Glyphosate	42	31	3	2
	NPNC	274	296	369	217
	Mean	150	152	164	78
CSCS	No glyphosate	77	66	202	19
	Glyphosate	32	0	3	2
	NPNC	280	198	606	249
	Mean	130	88	270	90
SCSC	No glyphosate	99	73	7	38
	Glyphosate	91	9	2	7
	NPNC	311	283	345	387
	Mean	167	122	118	144
SSCC	No glyphosate	44	17	87	59
	Glyphosate	37	2	6	7
	NPNC	228	166	487	396
	Mean	103	62	193	154
SSSS	No glyphosate	83	18	6	2
	Glyphosate	82	0	3	2
	NPNC	362	195	306	144
	Mean	175	71	105	49
Mean	No glyphosate	85	74	130	65
	Glyphosate	54	9	3	5
	NPNC	293	232	448	303
LSD (0.05)					
Rotation		NS	46	136	88
Herbicide		64	32	96	44
Interaction		NS	NS	NS	119

<sup>a</sup> Abbreviations: C, cotton; NPNC, herbicide program with no purple nutsedge control; S, soybean.

<sup>b</sup> Data were recorded on July 28, July 7, June 26, and June 25 in 1998, 1999, 2000, and 2001, respectively.

<sup>c</sup> Non-glyphosate herbicide program included metolachlor at 1.1 kg ai/ha, fluometuron at 1.1 kg ai/ha, and pyriithiobac at 0.04 kg ai/ha preemergence (PRE) followed by (fb) pyriithiobac at 0.08 kg ai/ha post emergence (POST) for cotton and metolachlor at 2.8 kg ai/ha PRE fb chlorimuron at 13 g ai/ha POST in soybean; the glyphosate-based program included glyphosate at the one-leaf stage fb glyphosate at the four-leaf stage in cotton; and glyphosate at the two- to three-trifoliate stage fb glyphosate at the four- to five-trifoliate stage in soybean; and the NPNC herbicide program included fluometuron applied at 1.1 kg ai/ha PRE and clethodim at 0.14 kg ai/ha POST in cotton and acifluorfen applied at 0.4 kg ai/ha and bentazon at 1.1 kg ai/ha POST in soybean. A dinitroaniline at 1.1 kg ai/ha (pendimethalin or trifluralin) PPI and clethodim at 0.14 kg ai/ha POST were applied to the entire experiment.

nutsedge populations decreased in continuous soybean compared with continuous cotton system in 1999, 2000, and 2001. Furthermore, higher purple nutsedge populations tended to be associated with cotton than with soybean, regardless of years of rotation. For example, CCSS vs. SSCC in 1999 and CSCS vs. SCSC in 2000 showed reductions or no increase in purple nutsedge populations in soybean. After 4 yr, purple nutsedge populations greatly decreased when cotton was rotated with soybean (CSCS and SCSC), compared with continuous cotton.

Table 2. Purple nutsedge shoot dry weight as affected by non-glyphosate- and glyphosate-based herbicide programs in 4-yr, narrow-row<sup>a</sup> glyphosate-resistant cotton and soybean rotation systems.<sup>a-c</sup>

Rotation system	Herbicide program <sup>d</sup>	Purple nutsedge shoot dry weight		
		1998	2000	2001
CCCC	No glyphosate	86	31	89
	Glyphosate	26	2	10
	NPNC	225	116	129
	Mean	112	50	76
CCSS	No glyphosate	227	8	16
	Glyphosate	28	1	5
	NPNC	553	57	58
	Mean	270	22	26
CSCS	No glyphosate	150	33	11
	Glyphosate	21	1	3
	NPNC	327	133	61
	Mean	166	56	25
SCSC	No glyphosate	101	2	35
	Glyphosate	97	2	5
	NPNC	413	66	87
	Mean	204	23	42
SSCC	No glyphosate	43	31	41
	Glyphosate	63	3	8
	NPNC	436	110	169
	Mean	181	48	73
SSSS	No glyphosate	56	1	4
	Glyphosate	94	1	4
	NPNC	491	54	45
	Mean	214	19	17
Mean	No glyphosate	110	17	33
	Glyphosate	55	2	6
	NPNC	407	89	91
LSD (0.05)				
Rotation		NS	27	29
Herbicide		86	19	15
Interaction		NS	NS	40

<sup>a</sup> Data not available for 1999.

<sup>b</sup> Abbreviations: C, cotton; NPNC, herbicide program with no purple nutsedge control; S, soybean.

<sup>c</sup> Purple nutsedge shoots were harvested on July 28, June 26, and June 25 in 1998, 2000, and 2001, respectively.

<sup>d</sup> Non-glyphosate herbicide program included metolachlor at 1.1 kg ai/ha, fluometuron at 1.1 kg ai/ha, and pyriithiobac at 0.04 kg ai/ha preemergence (PRE) followed by (fb) pyriithiobac at 0.08 kg ai/ha postemergence (POST) for cotton and metolachlor at 2.8 kg ai/ha PRE fb chlorimuron at 13 g ai/ha POST in soybean; the glyphosate-based program included glyphosate at the one-leaf stage fb glyphosate at the four-leaf stage in cotton; and glyphosate at the two- to three-trifoliolate stage fb glyphosate at the four- to five-trifoliolate stage in soybean; and the NPNC herbicide program included fluometuron applied at 1.1 kg ai/ha PRE and clethodim at 0.14 kg ai/ha POST in cotton and acifluorfen applied at 0.4 kg ai/ha and bentazon at 1.1 kg ai/ha POST in soybean. A dinitroaniline at 1.1 kg ai/ha (pendimethalin or trifluralin) PPI and clethodim at 0.14 kg ai/ha POST were applied to the entire experiment.

Among herbicide programs, both glyphosate- and non-glyphosate-based programs reduced purple nutsedge populations compared with NPNC in 1998 (Table 1). In subsequent years, the glyphosate-based program was more effective in reducing purple nutsedge populations, compared with the non-glyphosate-based program.

Purple nutsedge shoot dry biomass did not differ among rotation systems in 1998 (Table 2). Purple nutsedge shoot dry biomass and density were higher in con-

Table 3. Cotton plant population at harvest and open bolls as affected by non-glyphosate- and glyphosate-based herbicide programs in 4-yr, narrow-row, glyphosate-resistant cotton and soybean rotation systems.<sup>a</sup>

Treatment/ herbicide <sup>b,c</sup>	Cotton plant population			Cotton open bolls		
	1999	2000	2001	1999	2000	2001
	plants/ha			open bolls/plant		
Rotation						
CCCC	214,400	184,400	188,900	3.4	2.9	2.0
CCSS	232,200	—	—	3.5	—	—
CSCS	—	183,300	—	—	3.1	—
SCSC	225,600	—	200,000	4.5	—	2.3
SSCC	—	176,700	177,800	—	3.8	1.9
LSD (0.05)	NS	NS	NS	0.6	NS	NS
Herbicide						
No glyphosate	243,300	226,700	226,700	4.2	3.7	2.8
Glyphosate	278,900	225,600	225,600	4.2	4.3	2.7
NPNC	150,000	92,200	114,400	3.0	1.8	0.6
LSD (0.05)	37,700	31,000	31,000	1.0	1.1	0.5

<sup>a</sup> Data not available for 1998.

<sup>b</sup> Abbreviations: C, cotton; NPNC, herbicide program with no purple nutsedge control; S, soybean.

<sup>c</sup> Non-glyphosate herbicide program included metolachlor at 1.1 kg ai/ha, fluometuron at 1.1 kg ai/ha, and pyriithiobac at 0.04 kg ai/ha preemergence (PRE) followed by (fb) pyriithiobac at 0.08 kg ai/ha post emergence (POST) for cotton and metolachlor at 2.8 kg ai/ha PRE fb chlorimuron at 13 g ai/ha POST in soybean; the glyphosate-based program included glyphosate at the one-leaf stage followed by glyphosate at the four-leaf stage in cotton; and glyphosate at the two- to three-trifoliolate stage followed by glyphosate at the four- to five-trifoliolate stage in soybean; and the NPNC herbicide program included fluometuron applied at 1.1 kg ai/ha PRE and clethodim at 0.14 kg ai/ha POST in cotton and acifluorfen applied at 0.4 kg ai/ha and bentazon at 1.1 kg ai/ha POST in soybean. A dinitroaniline at 1.1 kg ai/ha (pendimethalin or trifluralin) PPI and clethodim at 0.14 kg ai/ha POST were applied to the entire experiment.

tinuous cotton than in continuous soybean. In 2001, 2 yr of cotton following soybean (SSCC) resulted in higher dry biomass compared with cotton following soybean (CSCS or SCSC). Among herbicide programs, both glyphosate- and non-glyphosate-based programs reduced purple nutsedge shoot dry biomass, compared with NPNC in 1998, and the glyphosate-based program was more effective in reducing purple nutsedge shoot dry biomass than the non-glyphosate-based program in 2001 (Table 1). Purple nutsedge shoot dry biomass was also less in soybean than in cotton in NPNC, which strongly suggests that soybean is more competitive with purple nutsedge than cotton (Table 2).

**Cotton and Soybean Plant Populations.** After a 4-yr period, soybean plant populations did not differ among crop rotation systems or herbicide programs (data not shown), and cotton plant populations did not differ among crop rotation systems (Table 3). Cotton plant populations were lower in NPNC than in glyphosate-based and non-glyphosate-based programs in 1999, 2000, and 2001 (Table 3). Cotton was more sensitive to interference from purple nutsedge than soybean. Cotton has

Table 4. Cotton and soybean yields as affected by non-glyphosate- and glyphosate-based herbicide programs in a 4-yr, narrow-row, glyphosate-resistant cotton and soybean rotation system.<sup>a,b</sup>

Treatment/ herbicide <sup>c</sup>	Seed cotton			Soybean yield		
	1999	2000	2001	1998	1999	2000
	kg/ha					
Rotation						
CCCC	2,850	2,070	1,500	—	—	—
CCSS	2,860	—	—	—	—	2,780
CSCS	—	2,070	—	—	3,680	—
SCSC	3,670	—	1,860	2,460	—	2,710
SSCC	—	2,580	1,440	2,560	3,490	—
SSSS	—	—	—	2,340	3,420	2,480
LSD (0.05)	640	NS	NS	NS	NS	NS
Herbicide						
No glyphosate	3,740	2,680	2,280	3,250	3,930	3,040
Glyphosate	4,070	3,490	2,190	2,260	4,020	2,890
NPNC	1,540	550	330	1,850	2,640	2,040
LSD (0.05)	640	670	430	640	600	700

<sup>a</sup> Abbreviations: C, cotton; NPNC, herbicide program with no purple nutsedge control; S, soybean.

<sup>b</sup> Data not available for 1998.

<sup>c</sup> Non-glyphosate herbicide program included metolachlor at 1.1 kg ai/ha, fluometuron at 1.1 kg ai/ha, and pyriithiobac at 0.04 kg ai/ha preemergence (PRE) followed by (fb) pyriithiobac at 0.08 kg ai/ha postemergence (POST) for cotton and metolachlor at 2.8 kg ai/ha PRE fb chlorimuron at 13 g ai/ha POST in soybean; the glyphosate-based program included glyphosate at the one-leaf stage fb glyphosate at the four-leaf stage in cotton; and glyphosate at the two- to three-trifoliolate stage fb glyphosate at the four- to five-trifoliolate stage in soybean; and the NPNC herbicide program included fluometuron applied at 1.1 kg ai/ha PRE and clethodim at 0.14 kg ai/ha POST in cotton and acifluorfen applied at 0.4 kg ai/ha and bentazon at 1.1 kg ai/ha POST in soybean. A dinitroaniline at 1.1 kg ai/ha (pendimethalin or trifluralin) PPI and clethodim at 0.14 kg ai/ha POST were applied to the entire experiment.

been shown to be more sensitive to allelopathic effects of purple nutsedge (Mastene-Diag, 1997).

**Cotton and Soybean Yields.** Seed cotton yield following soybean (SCSC) was higher compared with cotton following cotton (CCCC, CCSS) in 1999 (Table 4). This higher yield can be attributed to more bolls produced per plant in SCSC (4.5 bolls/plant), compared with less than 3.5 bolls/plant in CCCC and CCSS rotation system (Table 3). However, seed cotton yields were similar regardless of crop rotation systems in 2000 and 2001 (Table 4), as was the case with bolls per plant (Table 3). Seed cotton yields were equivalent in the glyphosate-based and non-glyphosate-based programs in 1999 and 2001 (Table 5). In 2000, seed cotton yield was higher in the glyphosate-based program (3,490 kg/ha) than in NPNC (2,680 kg/ha). These differences in seed cotton yield were largely due to differences in cotton bolls per plant. Cotton bolls per plant were greatly reduced in NPNC compared with the glyphosate- and non-glyphosate-based programs in 1999, 2000, and 2001 (Table 3). Overall, in all 3 yr (1999 to 2001), seed cotton yields

Table 5. Effect of narrow-row, glyphosate-resistant cotton and soybean rotation and herbicides on purple nutsedge tuber (November 2001) and plant density (May 2002) after termination of a 4-yr study in 2001.<sup>a</sup>

Rotation system	Herbicide program <sup>b</sup>	Purple nutsedge	
		Tubers, November 2001	Plants, May 2002
		tubers/soil core <sup>c</sup>	plants/m <sup>2</sup>
CCCC	No glyphosate	5.7	284
	Glyphosate	1.1	12
	NPNC	11.6	482
	Mean	6.1	259
CCSS	No glyphosate	0.7	8
	Glyphosate	0	0
	NPNC	2.7	70
	Mean	1.1	26
CSCS	No glyphosate	0.5	6
	Glyphosate	0	1
	NPNC	5.5	98
	Mean	2.0	35
SCSC	No glyphosate	0.7	30
	Glyphosate	0	8
	NPNC	9.7	322
	Mean	3.5	120
SSCC	No glyphosate	2.8	112
	Glyphosate	0.1	24
	NPNC	6.3	352
	Mean	3.1	163
SSSS	No glyphosate	0.5	0
	Glyphosate	0	1
	NPNC	1.7	118
	Mean	0.7	40
Mean	No glyphosate	1.8	73
	Glyphosate	0.2	8
	NPNC	6.3	240
LSD (0.05)			
Rotation		2.3	90
Herbicide		1.3	64
Interaction		3.2	157

<sup>a</sup> Abbreviations: C, cotton; NPNC, herbicide program with no purple nutsedge control; S, soybean.

<sup>b</sup> Non-glyphosate herbicide program included metolachlor at 1.1 kg ai/ha, fluometuron at 1.1 kg ai/ha, and pyriithiobac at 0.04 kg ai/ha preemergence (PRE) followed by (fb) pyriithiobac at 0.08 kg ai/ha postemergence (POST) for cotton and metolachlor at 2.8 kg ai/ha PRE fb chlorimuron at 13 g ai/ha POST in soybean; the glyphosate-based program included glyphosate at the one-leaf stage fb glyphosate at the four-leaf stage in cotton; and glyphosate at the two- to three-trifoliolate stage fb glyphosate at the four- to five-trifoliolate stage in soybean; and the NPNC herbicide program included fluometuron applied at 1.1 kg ai/ha PRE and clethodim at 0.14 kg ai/ha POST in cotton and acifluorfen applied at 0.4 kg ai/ha and bentazon at 1.1 kg ai/ha POST in soybean. A dinitroaniline at 1.1 kg ai/ha (pendimethalin or trifluralin) PPI and clethodim at 0.14 kg ai/ha POST were applied to the entire experiment.

<sup>c</sup> Soil core size was of 9.5 diam and 15.2 cm depth.

were reduced by 62 to 85% in NPNC, compared with yields in glyphosate- and non-glyphosate-based programs. The seed cotton yield reduction caused by purple nutsedge (62 to 85%) in the NPNC in this study was greater than that (45%) reported by Guantes and Mercado (1975).

Soybean yield was unaffected by crop rotation systems in all the 4 yr (Table 4). Among herbicide pro-

grams, the non-glyphosate-based program in all 4 yr and the glyphosate-based program in 1999 and 2001 provided higher soybean yield compared with NPNC. Soybean yield did not differ between the glyphosate-based and the non-glyphosate-based programs, except in 1998.

**Purple Nutsedge Tuber and Plant Density after 4-yr Rotation.** After 4 yr of rotation, in the fall of 2001, tubers per soil core (9.5 cm in diameter and 15.2 cm deep) were highest in continuous cotton (6.1 tubers/core) and lowest in continuous soybean (0.7 tubers/core) (Table 5). A similar trend was observed for purple nutsedge density in the spring of 2002 (Table 5). Two years of cotton following soybean (SSCC) resulted in higher purple nutsedge density compared with cotton following soybean (CSCS). The glyphosate-based and the non-glyphosate programs with activity on purple nutsedge reduced tubers per core and plant density compared with NPNC, and the glyphosate-based programs was more effective than the non-glyphosate-based program in reducing tubers per core and plant density. Among interactions, the glyphosate-based program was more effective than the non-glyphosate-based program in reducing tubers per core and plant density in continuous cotton (Table 5). In contrast, in continuous soybean, both tubers per core and plant density were similar, regardless of herbicide programs. Furthermore, in NPNC, both tubers per core and plant density were higher in continuous cotton vs. continuous soybean and SSCC or SCSC vs. CCSS or CSCS. These data further indicate that soybean competes more effectively with purple nutsedge than cotton. In cotton production, severe infestations of purple nutsedge may be managed by rotating cotton with soybean compared with continuous cotton and by using a glyphosate-based program in glyphosate-resistant cotton.

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